Available online at www.sciencedirect.com
SciVerse ScienceDirect
Energy Procedia 17 (2012) 1109 – 1115
Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

Power Line Galloping Acceleration Sensor Location Algorithm

Huang Xinbo,Li Guochang,Tao Baozhen,Wei Yanhui

College of Electronics and Information,Xi ' an Polytechnic University,Xi ' an, China

Abstract

In practice, many cases need acceleration signal into the displacement. Combined with the practical application of transmission wire dancing, using fourier transform, the least squares, digital filtering, frequency domain integral etc. Put forward a kind of acceleration signals converts the displacement of the frequency domain analysis method. Finally, do the related experiments of one-dimensional displacement, two-dimensional displacement and three-dimensional displacement. The results show that the algorithm is high precision, and can be used for transmission wire dancing monitoring.

Keywords: power line galloping ;accelerometer ;frequency domain integral ; digital filter

1.Introduction

In recent years, the influence of global climate in big snow disaster weather increasingly frequent, overhead transmission lines wire cladding ice dancing, often happens, direct threat to our security operation of transmission lines [1]. Due to the transmission line without rigid structure can't directly mounted displacement sensor measuring displacements [2]. Using the acceleration sensor is an effective displacement measures. Theoretically acceleration signal by two points can get displacement, but in tests of collected data, due to the acceleration signal amplifier and change with the temperature sensor of zero drift, outside the scope of the low frequency stability and performance of the surrounding environment, sensor tend to produce larger trend of [3], together with the accumulation of error,[1] the process of integration has greatly influenced the displacement of measurement accuracy.

1 Foundation item: National Basic Research Program (973 Program, 2009CB724507-3).

 doi:10.1016/j.egypro.2012.02.215

2.Transmission Wire Dancing On-line Monitoring

At present, the main methods wire dancing monitoring image remote monitoring, computer simulation is adopted[1], in this paper the acceleration sensor based on on-line monitoring method of dancing. As shown in figure 1, transmission distance for overhead in AB section, several points were selected in AB, install wireless sensor node acceleration. Through three direction of the acceleration sensor measurements, and the monitoring center expert software can be for each data pretreatment, digital filter, and points out that the displacement of wire fitting curve.

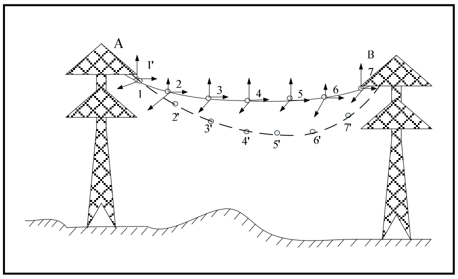

Figure 1.the installation of wireless acceleration sensor node diagram

3.Acceleration Signal Acquisition And Pretreatment

3.1.Signal Acquisition

The data acquisition module composed mainly by CC2430 Radiofrequency chip, ADXL330 sensor and Power system , In a single chip, CC2430 used 8051MCU enhanced, 64K flash, and 8KB RAM, and bring the high-precision AD converter. Only adding simply a simple circuit can realize the periphery of wire dancing acceleration sensor signal acquisition.

3.2.Eliminate Direct Current Component and Trend

DC component and the presence of key trends have a great impact integral transform. Displacement curve obtained may have distorted or even distortion.

- *The Average method to eliminate Direct Current component*

Remove DC component is generally selected to mean method [4], namely the n sampling points average:

$$\bar{X} = \frac{1}{n}\sum_{i=0}^{n-1} X_i \tag{1}$$

Then use the value minus the average data:

$$X_i' = X_i - \bar{X} \qquad (i=0,1,2,...n-1) \tag{2}$$

- *Least-square method to eliminate trend.*

The method of eliminating trend is similar to the principle of curve fitting. Fitting function can choose polynomial, index, trigonometric function etc, which can according to the distribution characteristics of test data. We choose polynomial least-square method to eliminate trend[3,5].

For example, a group of acceleration sampled data (x_i, y_i) i = 1, and... n, set a polynomial fitting function for:

$$\theta(x) = a_0 + a_1x + a_2x^2 + ... + a_nx^n = \sum_{i=0}^{n} a_i x^i \tag{3}$$

Determine the function coefficients a_i, That meet with the minimum error square between discrete data y_i and function $\theta(x)$, that is:

$$S(a_0, a_1, a_2, ..., a_n) = \sum_{i=1}^{m}[\theta(x_i) - y_i]^2$$
$$= \sum_{i=1}^{m}[\sum_{j=0}^{n} a_j x^j - y_i]^2 \tag{4}$$

Function S is the nonnegative quadratic function, which independent are a0, a1, a2,... an, and satisfy the conditions of extreme for:

$$\frac{\delta S}{\delta a_k} = 0 \qquad (k=0,1,2...n) \tag{5}$$

That is:

$$\sum_{i=1}^{m} x^i [\sum_{j=0}^{n} a_j x^j - y_i] = 0 \qquad (k=0,1,2,...n) \tag{6}$$

In this take S partial differentiation of a_j, can have a m +1 times linear equations, the solution of equations of undetermined coefficients a_j can be determined, then can determine fitting function.

A formula for eliminating trend:

$$z_j = y_j - \theta(x_j) \qquad (j=1,2,...n) \tag{7}$$

A combination of the two methods, using MATLAB language of DC component and trend of elimination. As shown in figure 2 for the test to a group of acceleration data, through comparing, can see the trend of processing, data is improved.

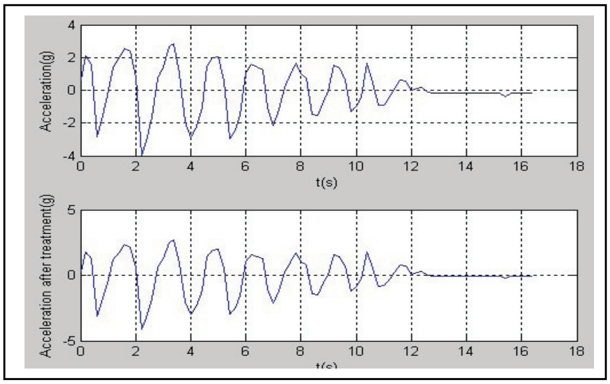

Figure 2. Comparison of curve acceleration signal changes

3.3.Digital Filtering

After removal of DC component and trend of computing, pass on FFT filtering can eliminate the sensor frequency range of performance instability frequency interference [3].

Firstly, the collected data points X(n), after the discrete Fourier transform a plural sequence X(k), and then to X(k) digital frequency domain, its expression filtering processing for:

$$y(r) = \sum_{k=0}^{N-1} H(k)\mathrm{X}(k)e^{j2\pi kr/N} \tag{8}$$

H(k) for filter, the frequency response function by it to determine the mode and the characteristic, the filter in ideal condition, bandpass filter the frequency response function for:

$$\mathrm{H(k)}=\begin{cases} 1 & f_d \le k\Delta f \le f_u \\ 0 & (other) \end{cases} \tag{9}$$

Formula: f_d is lower cut-off frequency and f_u is maximum cut-off frequency, Δf is the frequency resolution.

4.Integral Operator

4.1.Time Domain Integral

Time Domain Integral is based on the principles of higher mathematics integration . Area under the curve can be seen as numerous small area of the trapezoid, namely for the integration of approximate size. The following is the principle of time-domain integral [6].

Assuming objects from moment t_0 to moment t_n at the way of variable motion, initial speed for v_0, displacement for s and acceleration for a_i (n = 1,2, ...n).According to the mathematical formulas available:

$$s=\int_0^n v_t dt=[\frac{1}{2}(v_0+v_1)\times(t_1-t_0)]+[\frac{1}{2}(v_1+v_2)\times(t_2-t_1)]+\ldots$$

$$\ldots+[\frac{1}{2}(v_{n-1}+v_n)\times(t_n-t_{n-1})] \tag{10}$$

Equal to one sampling interval, denoted Δt .This formula is simplified to:

$$s=\int_{t_0}^{t_n} v_t dt=[\frac{1}{2}(v_0+v_n)+v_1+v_2$$

$$+\ldots+v_{n-1}]\times\Delta t \tag{11}$$

And the relationship with v_n and v_0 can be:

$$s=\int_0^n v_{(t)}dt=n\times v_0\times\Delta t+[(n-1)a_1+(n-2)a_2++\ldots\ldots+a_{n-1})\times\Delta t^2+\frac{1}{4}(a_0+a_n)\times\Delta t^2 \tag{12}$$

By using the method of simulation by MATLAB, the displacement Figure 3 shows. We can see the deflection displacement of simulation and actual displacement are very serious distortion(the actual displacement 1 m).The main reasons are: First of all, to simplify operations in the calculation, the initial velocity and initial displacement of default is zero. Secondly, the integrated error accumulation problem. A small signal interference was amplified after numerous operations continued. In addition, the low frequency signal amplification also has great influence on the result points.

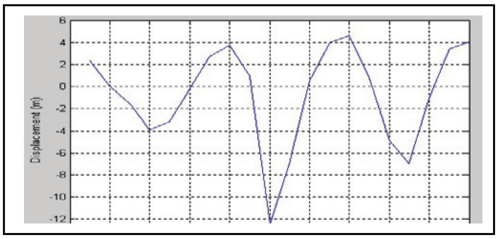

Figure 3. Displacement transform time-domain integral curve

4.2.Frequency Domain Integral

Frequency domain analysis is based on Fourier transform based on time, and the results are of variable frequency for function. Its basic principle is signal for Fourier transform, and then transform results in frequency domain, and finally the Inverse Fourier transform[3].

- *First of fourier transform*

Any periodic signals can be decomposed into many different frequency signal of virtual index. The length of the continuous signal x(t), the discrete data sampling after x(n), use MATLAB function in FFT(x,n) in the rapid discrete Fourier transform, can get a plural sequence x(k).

- *Next to the plural sequences, and joined the integral computation of digital filter[3], the calculation formula for:*

$$y(r) = \sum_{k=0}^{N-1} -\frac{1}{(2\pi k\Delta f)^2} H(k)x(k)e^{j2\pi kr/N} \tag{13}$$

Formula: f_d is lower cut-off frequency and f_u is maximum cut-off frequency, Δf is the frequency resolution.

- *Finally, the results of the inverse Fourier transform integral In fact, by the Department and took the time domain signal.*

Through the analysis of two algorithms, we can see that, compared with the time domain and integral frequency domain, integral algorithm is relatively complex, but relatively stable. The displacement of the graphics can reflect the actual object. The system adopts the frequency domain integral method .

5.Experiment

Be installed in the ZigBee wireless acceleration sensor on the module (RFD), and module can be free movement. Data using ZigBee receiver(Coordinator), responsible for tuner node receiving acceleration data, and through Serial Debugging Assistant to computer, finally computer use MATLAB simulation software for data processing, testing devices shown in figure 4.

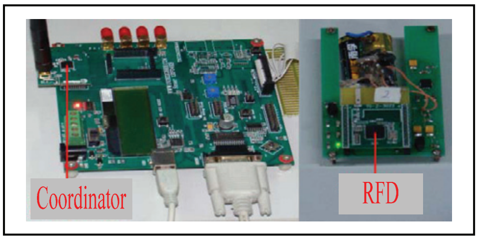

Figure 4. Experimental Test Devic

5.1.One-dimensional Displacement Test

Acquisition module on the platform, make periodic motion along the straight line acceleration curve and displacement curve shown in figure 5 respectively.

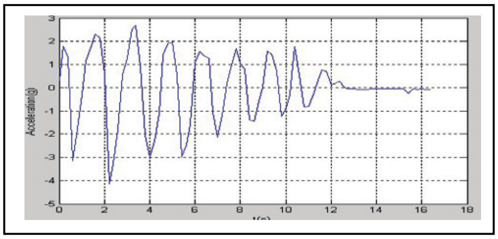

Figure 5. Acceleration curve

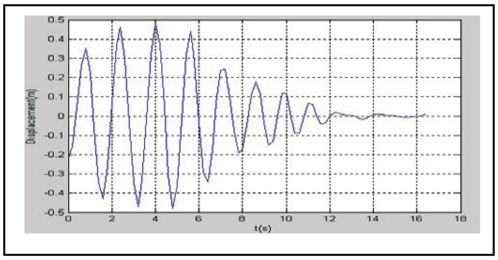

Figure 6. Displacement curve

Compared with diagram displacement amplitude and acquisition module actual mobile distance (tape scale) to movements. Actual mobile distance are as follows: the first cycle, module displacement amplitude is 0.4 meters, The next three cycles displacement amplitude is 0.5 meters, From the five cycle begins, module displacement decrease gradually until stop.

5.2.Two-dimensional Displacement Test

Acceleration sensor test platform in the x axis deviation Angle, linear motion simulation results as shown in figure 7:

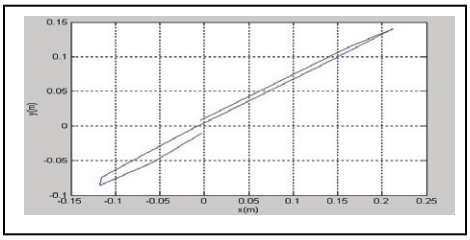

Figure 7. Two-dimensional displacement

The graphics and the actual movement distance comparison. Modules from actual x axis into 30 degrees, do reciprocating motion, and amplitude along the x-axis direction of projection is 0.2 m, along the y direction projection amplitude is 0.15 meter.

5.3.Three-dimensional Displacement Test

The acceleration sensor in doing approximate ellipsoid movement, and the simulation results as shown in figure 8:

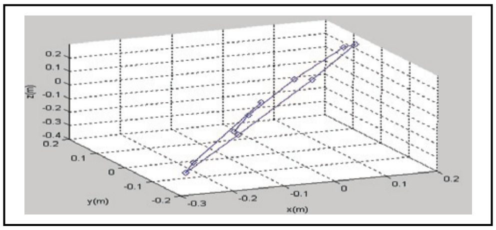

Figure 8. Three-dimensional displacement

The graphic comparison with the actual movement distance. Module actual trajectory at x, y, z projection of the three directions were 0.2 meters, 0.1 meters, 0.25 meters, and graphic simulation of can reflect the actual movement trend.

6.Conclusion

In this article, by using the least squares, digital filtering algorithm for signal pretreatment, and through the time domain and frequency domain two cases of integral, we can see frequency domain integral effect is good. The method is accurate, can be used for conductor galloping, and other works in vibration signal processing.

References

[1] Huang Xinbo. Transmission-line monitoring and fault diagnosis [M]. Beijing: China Electric Power Press,2008.

[2] Liu Jicheng, Xu Qinghua, Cha Jianxin. With the acceleration sensor method of vibration displacement[J]. Radar. 2007,29(5):69-71.

[3] Wang Ji, HuXiao, MATALB in vibration signal processing[M]. ChinaWater Power Press,2006.

[4] Li Dongwen, Xiong Xiaoyan, LiBo. Signal processing of vibration acceleration[J]. Electrical Engineering Technology.2008,37(09):50-52.

[5] Zhong Erjie,Huang Tingzhu. Numerical Analysis.[M]. BeiJing: Higher Education Press,2003.

[6] Cheng Yihua. Acceleration sensor-based positioning system[D]. XiamenUniversity.2006.